



BFGoodrich Aerospace
Aircraft Integrated Systems



Open Systems, A Collaboration Case Study

Integrated Mechanical Diagnostics (IMD) Health & Usage Monitoring System (HUMS)

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Outline

- Terms and Definitions
 - What is IMD HUMS?
 - What are Open Systems?
- Government and Contractor Perspectives
- Spirited Discussion
- The Chosen Path
- JAHUMS Technology Insertion
- Lessons Learned and Conclusions

IMD HUMS

- *IMD HUMS is a Commercial Operations & Support Saving Initiative (COSSI) to improve helicopter operational readiness and flight safety while slashing maintenance-related costs.*
- *The U. S. Navy (USN) has partnered with BFGoodrich to field this military/commercial “dual use” HUMS.*
 - *H-53Es / SH-60s / CH-60s / S-92 / S-76C / S-76A (FAA)*
 - *FY99 COSSI awards: UH-1Y / AH-1Z / UH-60s*

IMD HUMS

Co-sponsored by
PMA-261 / PMA-299 / BFGoodrich / DARPA
NRE Funding (\$9M DARPA/\$9M BFG)

- **FY97 COSSI Award**
- **Acquisition Reform - 845 Agreement**
- **Derivative of COTS system modified to meet military requirements of:**
 - Open Systems
 - Information Management / Interface to NALCOMIS
 - Mil. Environment
- **Anticipated Benefits:**
 - Improved A/C Safety
 - Increased Availability & Reliability
 - Rapid Determination of A/C Status
 - Reduced O&S Costs
 - Decreased MMH/FH
 - Reduced Scheduled Component Removals
- **Functions:**
 - Continuous RT&B
 - Rotor System Diagnostics
 - Engine Performance. & Diagnostics
 - Gearbox & Drive-train Diagnostics
 - Structural Usage & Fatigue Life Tracking
 - Maintenance Trending
 - FDR/CVR
- **Prototypes:**
 - 1 CH-53E & 1 SH-60F @ RWATS
 - 5 CH-53E @ HMT-302
 - 5 SH-60B @ 2- HSL-40/3-HSL-41
- **Final Product will be Dual Use**

IMD-COSI 845 Agreement

- 10 USC 2371, Section 804 Of National Defense Authorization Act of 1997
- Revised 10 USC 2371, Section 845 of National Defense Authorization Act of 1994
- Director of DARPA and Secretaries Of Military Departments may use “other transactions” for prototype projects that are directly relevant to weapons systems proposed to be acquired or developed by the DOD
- 3 Year Authorization
- BFG retains data and patent rights
- BFG provides contractor logistics support
- BFG provides open architecture to enable 3rd party P³I efforts
- 57 payable milestones
- Navy retains title to prototypes developed under the agreement and “march-in” rights to data if BFG fails to perform

Open Systems

- **Open Systems Architecture**
 - Technology insertion and refresh
 - Transportability / Scalability / Interoperability
 - Lower life cycle cost
 - Use of open commercial interface standards
 - Keeps competition focused on the underlying technologies
- **Navy IMD Team working OS issue since Mar 96**
 - IMD intended to meet requirements for all Navy Helicopters
 - Received guidance and training from the Open System Joint Task Force
 - HUMS industry not interested in Open Systems in 1996
- **Changes over last 2 years**
 - IMD HUMS effort makes clear the Navy's commitment to OS
 - Significant architectural changes being seen across the industry
- **Open Systems Verification**
 - Draper Labs & OSD's OSJTF assessment of open system specification
 - JAHUMS - Joint Advanced Health & Usage Monitoring System (ACTD) - 5 modules to be integrated without proprietary data exchange

What are Open Systems?

– “An Open Systems approach is a business and engineering strategy to choose specifications and standards ...

- Adopted by industry standards bodies *or*
- De facto standards (set by the market place) for selected systems interfaces (functional & physical), products, practices, and tools.”

• *DOD 5000.2-R, 23 March 1996*

What are Open Systems? (contin.)

- **Open Systems ...**
- Have well-defined, widely used, nonproprietary interfaces and/or protocols
- Provide for expansion or upgrade by incorporating or adding new technology
- Use industry standards to define interfaces
- Use performance based specifications
 - » *DoD Open Systems Joint Task Force*
- Open Systems is understood to include both technical and business issues

Traditional Government Perspective

The Government wants ...

- All requirements met, even if we don't clearly identify them all up-front
- Accommodate growth and be transportable to other platforms
- Have the contractor share the risk and cost burden
- Never have to worry about system obsolescence
- See a wider choice of P³I capabilities, even from other contractors and vendors.
- Be good stewards of the taxpayers' \$\$\$
- Be a hero and get promoted

Traditional Contractor Perspective

The contractor wants ...

- Sell a high volume of the existing product and make \$\$\$ for the company
- Minimize system change and attendant cost and risk
- Maximize the Government's financial investment and minimize my own cost risk
- Solidify my competitive advantage now and for the long term
- Keep stockholders and management happy; show a quick profit.
- Target other applications for the product
- Be a hero and get promoted

IMD Open Systems Implementation

- **Payable milestone for an Open System Specification**
 - Details the interfaces available for ANY 3rd party vendor to insert a HUMS technology into the BFG system
 - Substantial cash payment for satisfactory specification
- **Independent assessment by Draper Labs concluded the spec documented a “limited open” system**
- **JAHUMS acts as strong forcing function!**
- **New milestone structured to remove the “limited” qualifiers**
- **Revised OS spec supports five distinct hardware and software technology insertion interfaces**
 - Intent is to support insertion of 3rd party technologies without any exchange of proprietary data

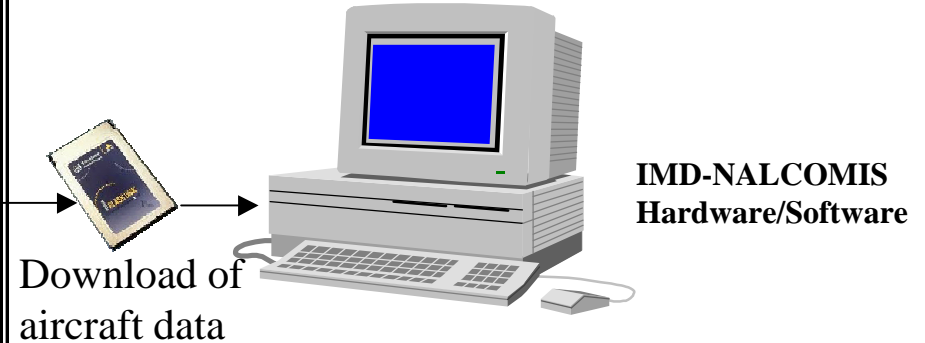
IMD HUMS Functional Overview

Airborne System



- **Acquire & Process Data**
- **Provide Advisories (if desired)**
- **Automates Functional Check Flights**
RT&B & Engine
- **Provides Maintenance Info to**
Troubleshooters
& FCF Pilots

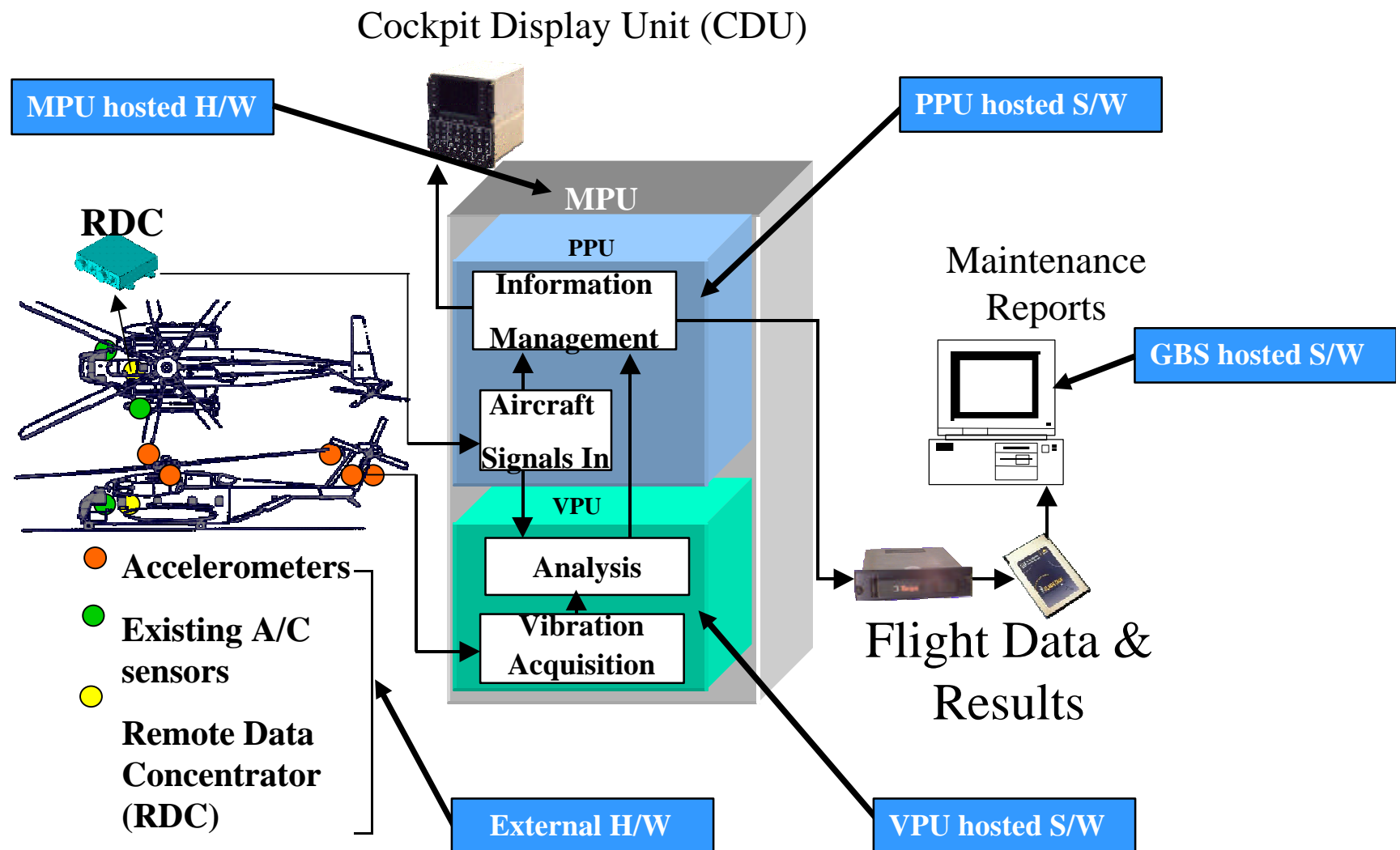
Ground Based System



- **Pilot Debrief**
- **Provides diagnostics/prognostics**
- **Identifies maintenance actions**
- **NALCOMIS Interface:**
Maintenance Management
Configuration Management
Serialized Parts Tracking
- **Interactive RT&B**
- **Apply usage**
Structural & Operational

Open System Architecture

Open System Interface Opportunities



Open Systems from a Technology Insertion Perspective

Why Open Systems?

A Modular Open Systems Approach is good for DOD

- Shortens acquisition cycle time by taking advantage of COTS technologies (e.g., CPUs, displays) → *(near term benefit)*
- Lowers total ownership costs by providing ready means for technology refresh and system upgrade (e.g., embedded software, mission computers etc) → *(far term benefit)*

Modular Open Systems also benefit industry for same reasons

unless... an individual company already has market place dominance (e.g., via existing product or infrastructure)

But, Open Systems implementation is not always easy

- Involves both technical & business issues with near/far term implications
- Requires up-front investment (e.g., identifying requirements, possibly reduced performance and/or higher NRE)

How do you know if the system delivered is really open?

HUMS - Assumptions & Expectations

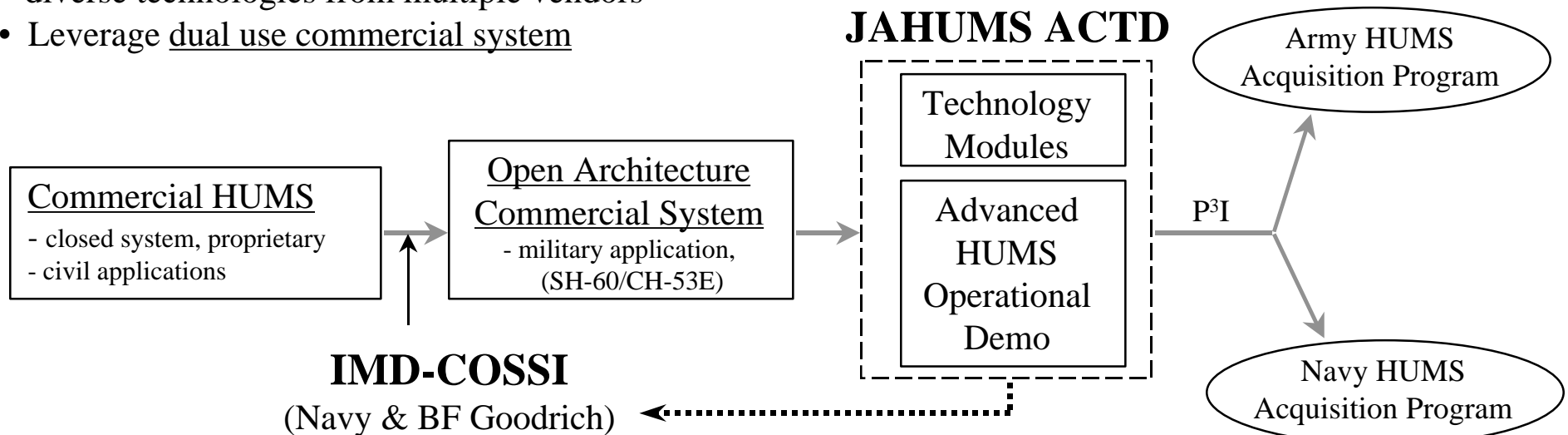
- Embedded diagnostics and prognostics are rapidly evolving.
- HUMS enables Condition Based Maintenance.
- Fully capable, user-friendly HUMS are not in widespread use, but they are proliferating on many fronts -- not just in aviation.
- Open Systems creates an opportunity for more technology players
- An open systems HUMS is a “platform” on which new technologies can ride.
- Networking & broad distribution of HUMS data likely to occur

Acquisition and Technology Insertion Approach



JAHUMS builds on the Navy's Lead the Fleet Program for Integrated Mechanical Diagnostics (IMD)

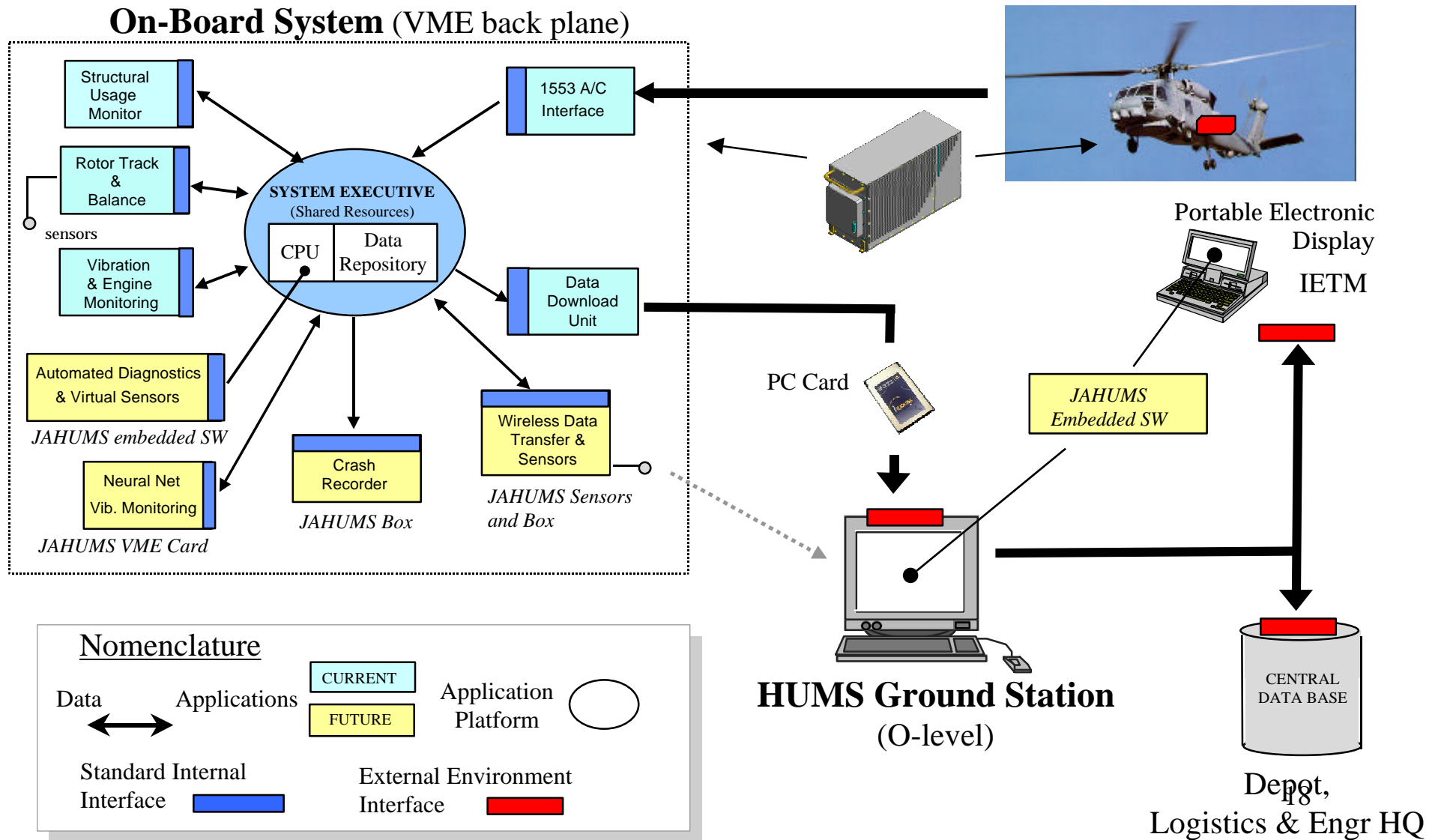
- Open systems to maximize application of diverse technologies from multiple vendors
- Leverage dual use commercial system



DUAL USE /COSSI (Phase I) - 50/50 industry/government cost share for development & production of 12 units, & requirement for open systems (*PMA-261 IMD Program Office*)

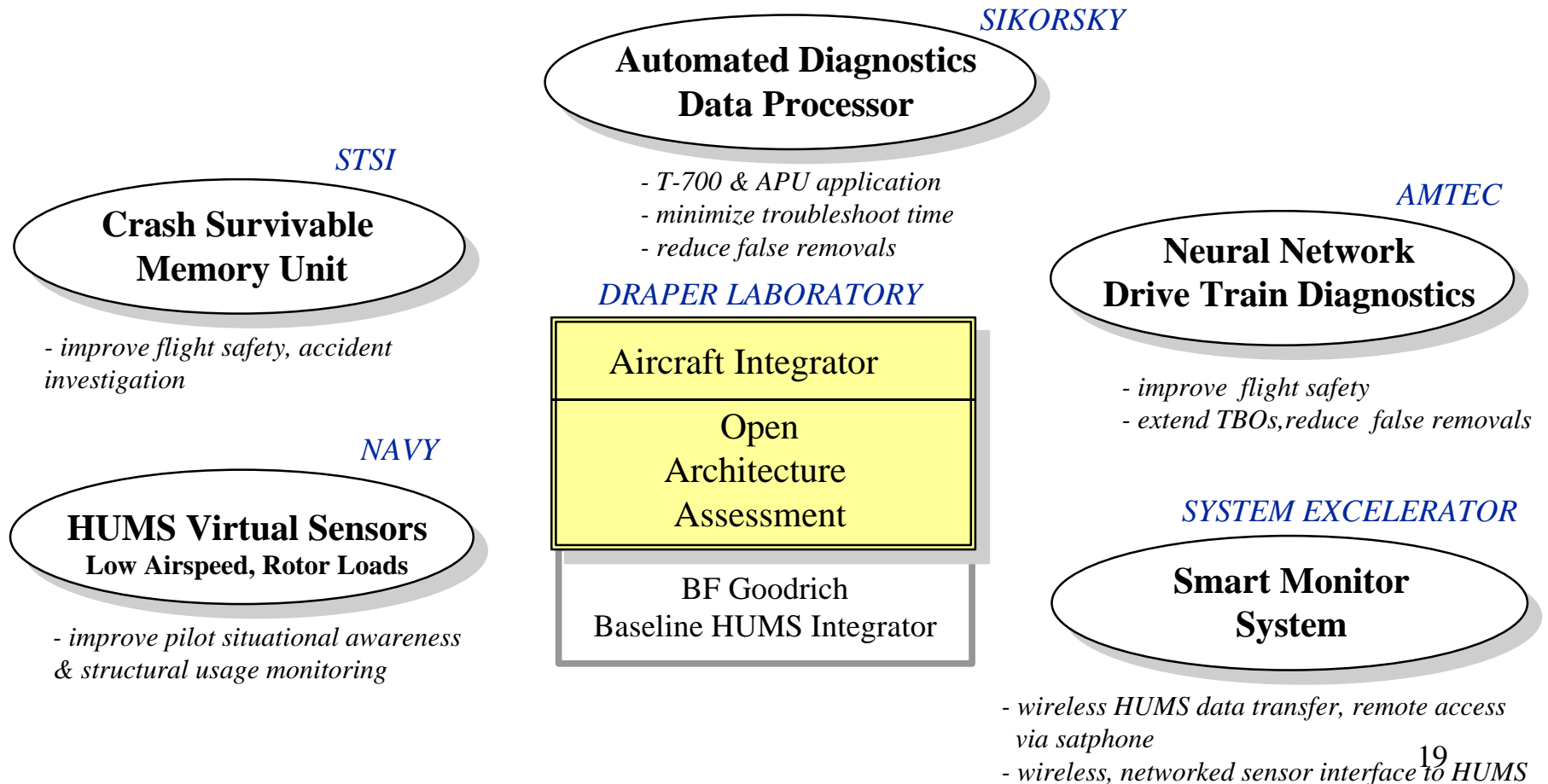
JAHUMS ACTD - demonstration/validation of open systems approach via technology insertion

HUMS Technical Reference Model



Diverse Mix of Technologies and Vendors in JAHUMS

Five technology modules proceeding into Phase II (design, build & test phase)



Nominal HUMS Business Environment

complex ... competitive ... evolving

Emerging requirements

- FAA/CAA (safety)
- CNO (policy for all platforms)
- DCS

1st gen HUMS - mandated for safety (civil) - closed systems / single developer
2nd gen HUMS - emphasis on maintenance benefits (military) - open systems

Emerging standards

RITA (industry)
NRTC (NASA/DOD)

HUMS suppliers

(system, technology level)

- BFG
- Smiths
- Eurocopter
- SHL
- SPS
- Chadwick
- Helitune
- GEC
- Teledyne
- MJA
- SEI

2nd tier suppliers

(technology, component level)

- sensors, electronics
- technology specialists
- >> multi-use focus (aircraft, ship, industrial)

U.S. Helicopter OEMs

(inherently involved in HUMS via aircraft safety & maintenance)

Boeing

- CH-47 Smiths UK
- CH-47 SHL / Smiths? USA
- AH-64 SHL USA/UK
- CH-46 Chadwick USN
- V-22 Bell/BFG USN

Sikorsky

- SH/UH-60 BFG USN/A**
- CH-53 BFG USN
- S-76 BFG civil
- S-92 BFG civil
- CH-53 Chadwick USAF
- RAH-66 embedded USA

Bell

- V-22 Bell / BFG USN
- 412 Bell / SHL Canada
- 412 Bell / SHL civil
- AH-1 BFG USN
- 609 SHL? civil

Users

Navy

(600 units)
BFG

Army

(4000 units)
BFG
Smiths
SHL

USAF/USCG

(125 units)
Chadwick
BFG
Helitune

UK/Foreign

(700+ units)
Smiths
Eurocopter

Civil

(1000+ units?)
SHL/Teledyne
GEC
....

Teamhawk H-60 Organization

Emerging diagnostic/prognostic technologies applicable to aircraft / ships / land vehicles and industrial applications

** JAH20MS aircraft

Many Lessons Learned

- **Detailed open systems implementation and certification guidelines are required**
- **Open systems approach involves both technical and business aspects. Both should be addressed early in the program.**
 - The open systems approach can represent a perceived threat to a company's intellectual property rights; industry may not embrace open systems
 - License fees/royalties, etc should be applicable at the production stage, not during the technology demonstration phase
 - The open systems approach is further complicated when the OEM or systems integrator also competes for technology insertion
 - Open systems requires an up-front investment
- **An open systems assessment & validation is best conducted by an experienced independent 3rd party, not the OEM or program office.**

In general, open systems approach is largely ad hoc

Open Systems Implementation Process (Strawman)

| <u>Who</u> | <u>How</u> | <u>When</u> | <u>What</u> |
|------------|---|-------------|---------------------------------|
| G | <u>Step 0:</u> Define what you want to accomplish & if open systems applies | MS-0 | Define what is wanted |
| G | <u>Step 1:</u> Trade studies to define open systems objectives and degree of openness desired | MS-I,II,III | |
| G / I | <u>Step 2A:</u> Develop an open systems <u>technical architecture</u> >> set of hardware/software interfaces that allow 3rd party COTS or advanced technology insertion at desired functional level of openness >> disclosed in the open systems specification | MS-II,III | Document it |
| I | <u>Step 2B:</u> Develop an open systems <u>business architecture</u> >> set of business rules & interfaces that enables & promotes free & open competition at the desired functional level of openness >> disclosed in the open systems business plan | MS-II,III | |
| G | <u>Step 3:</u> Independent assessment of documentation from step 2 | MS-II | |
| G / I | <u>Step 4:</u> Demonstrate & validate open architectures (DT/OT?) | MS-III | Demonstrate it |
| G? | <u>Step 5:</u> Certification of open systems process (envisioned as “ISO-9000 like”) | MS-III | |
| G / I | <u>Step 6:</u> Continuous improvement & life cycle support of open systems architectures and periodic re-certification as architectures change | continuous | Ensure system delivered is open |

G - government
I - industry

Open systems process is iterative and continuous over the life cycle of the system

Nominal Architecture Attributes

Technical architecture describes:

- system software, hardware and information/data interface standards
- publicly available data & system resources
- overview of system architecture, data flow
- sufficient to allow 3rd party to design & demonstrate technology using only publicly available data
- open systems technical reference model
- P³I impact on architecture
- functional/interface testing

Nominal Architecture Attributes

(contin.)

Business architecture describes:

- level at which competition is expected (e.g., sensor, board, functional level, etc.)
- key business processes that assure competition
- role of the systems integrator
- examples of vendor base that will participate in system improvements & any restrictions on vendor participation
- data rights for the government & industry partners
- open systems business reference model
- license process for government & privately owned technologies
- how open systems will be supported over the life cycle
- availability & access of baseline system to vendors for testing & demonstration

Note: We are still working through many business issues!

Resolving the Traditional Viewpoints

A successful Government/Industry collaboration ...

- Forges a team commitment to deliver the best product to the warfighters and in this case commercial operators
- Plans an approach to accommodate evolving requirements, advancing technology, and unanticipated circumstances as a TEAM
- Recognizes the contractor's legitimate business interests without compromising the Taxpayers interests
- Leaves neither side feeling like they have been taken advantage of

Conclusions

- Addressing technology insertion at the beginning of the acquisition process provides a good opportunity to capture the open systems methodology, cost/benefits & lessons learned for the HUMS community & acquisition community at large.
- Government must understand and respect the contractor's business issues associated with changing an existing product to make it more “open”.
- Industry must learn that Open Systems is a win-win and that workable business architectures can be developed jointly with the government

QUESTIONS

Acknowledgements & Open Systems Points of Contact

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* JAHUMS with BFG as an industry partner has been designated an OSJTF Open Systems Pilot Program